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Nordic Centre for Luminescence Research

Visible and UV light sources based on nonlinear interaction of lasers

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1. Abstract

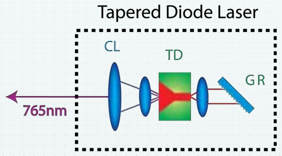
Different light sources can be used for optically stimulated luminescence measurements. Usually a halogen lamp in combination with filters or light emitting diodes (LED's) are used to provide the desired stimulation wavelength. However lasers can provide a much more well-defined beam, very narrow spectrum, high intensities and fast pulsing characteristics. Apart from potential significant reduction in filtration requirements as compared to the LED's, these characteristics help in accurate examination of different trap parameters. In this poster recent work on a general approach for effectively synthesizing any wavelength in the visible and ultraviolet light based sum frequency generation between two lasers is presented.

2. Introduction

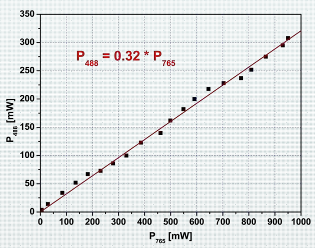
The development of efficient, compact and robust laser sources in the visible and UV spectral range is the subject of intensive research, for applications in areas as diverse as optical spectroscopy, projection displays, bio- and chemical sensing, and biomedical diagnostics. The generation of visible light from optically-pumped solid-state and semiconductor lasers is usually achieved via second harmonic generation (SHG), as the transition lines of most conventional doped dielectric laser crystals and the bandgaps of the most common III-V semiconductor alloys are in the near infrared region (NIR).
Using this general approach based on sum frequency generation (SFG) between two laser sources, effective generation of light can be achieved at hard to get wavelength, and "green noise" can be avoided.

4. Continuous Wave 488nm generation (Blue)

Single pass source : 765nm Tapered diode
Resonant laser : 1342nm Nd:YVO_4



Tapered diode (TD) in the Littrow configuration for single frequency operation. CL: Cylindrical lens. GR: Grating



Single pass slope efficiency for a circulating 1342nm power of 200W.

488nm was picked as a proof of principle and to demonstrate a small and compact alternative to the Argon Ion gas laser.

More than 300mW 488nm light was generated with a single pass conversion efficiency of 32%

Previous to this work generation of more than 700mW of 593nm has been demonstrated.

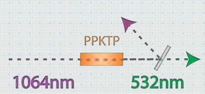
This offers a viable and better alternative to the blue LED's in OSL measurements.

6. Pulsed 340nm generation (UV)

Single pass source : 1064nm Q-Switch Nd:YAG laser
Resonant laser : 946nm Nd:YAG

→ **Second harmonic generation:** 532nm

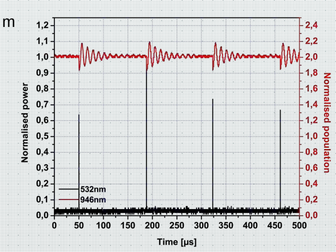
$$2\omega_{1064} = \omega_{532}$$



→ **Sum frequency generation:** 340nm

$$\omega_{532} + \omega_{946} = \omega_{340}$$

Present sub milliwatt generation of 340nm has been demonstrated



Generation of 340nm light occur when a 532nm pulse (black line) is incident on the nonlinear crystal and the relaxation oscillation for the 946nm laser is seen (red line)

3. Singly resonant setup

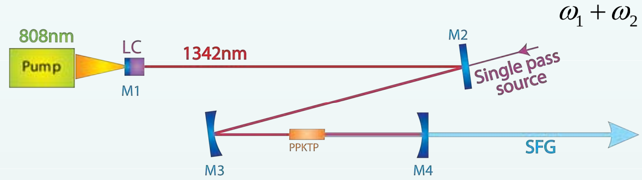
- Nonlinear media placed intracavity in one of the lasers
- No coupling between the modal gain of the two lasers
- High single pass convertion efficiency

Second Harmonic Generation

$$2\omega_1 = \omega_{SHG}$$

Sum Frequency Generation

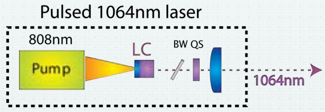
$$\omega_1 + \omega_2 = \omega_{SFG}$$



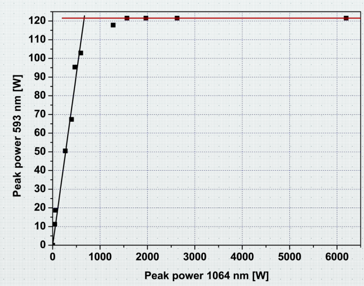
Setup for the resonant 1342nm Nd:YVO_4 solid state laser. M1-M4 are HR@1342nm and HT@808nm, λ_{SP}, λ_{SFG}
The resonator is end pumped by commonly 808nm Broad area laser diode.
The nonlinear crystal is a periodically poled KTP quasi phase matching the sum frequency interaction.
Appropriate choice of single pass source is effectively converted to the desired wavelength.

5. Pulsed 593nm generation (Yellow)

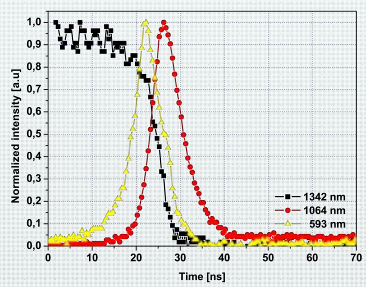
Single pass source : 1064nm Q-Switch Nd:YAG laser
Resonant laser : 1342nm Nd:YVO_4



1064nm solid state Nd:YAG (LC) laser with a Cr:YAG passive Q-switch (QS). The Brewster window forces oscillation at one polarisation.



Saturation of the peak power of the generated 593nm light as function of the 1064nm peak power for a 1342nm circulating power of 50W .



Dynamic of the interaction during single pass pulse propagation through the PPKTP. The resonant power is completely dumped for a single pass peak power of 2.4KW

7. Conclusions

- Using the proposed general approach, more than 300mW of CW of 488nm light was generated.
- Pulsed operation was demonstrated by generating 120W of 593nm peak power with a FWHM of 7ns.
- Pulsed generation of 340nm UV light through a cascaded process generating sub milliwatt average power was demonstrated.
- Synthesizing of any wavelength in the visible and UV spectral region, with high efficiency for both pulsed and continuous wave can be realized using this approach.
- These visible light sources generate sufficient power and can have flexible pulsing characteristics (ns timescale) to replace LED's for dedicated OSL applications such as excitation spectroscopy and time resolved OSL measurement.

8. References

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